U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-269 844

Council Grove Reservoir
Morris County, Kansas

National Eutrophication Survey, Corvallis, Oreg

Prepared for

Corvallis Environmental Research Lab, Oreg

Apr 77

PB 269 844

U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY

WORKING PAPER SERIES

CORVALLIS ENVIRONMENTAL RESEARCH LABORATORY - CORVALLIS, OREGON
and
ENVIRONMENTAL MONITORING & SUPPORT LABORATORY - LAS VEGAS, NEVADA

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE

Report
on
Council Grove Reservoir
Morris County
Kansas
EPA Region VII
Working Paper No. 512

With the cooperation of the
Kansas Department of Health and Environment
and the
Kansas National Guard
April, 1977

TECHNICAL REPORT DATA (Please read Instructions on the reverse before completing)	
1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE Report on Council Grove Reservoir, Morris County, Kansas		5. REPORT DATE Prepared April 1977 6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Anonymous (National Eutrophication Survey Staff)		8. PERFORMING ORGANIZATION REPORT NO. Working Paper # 512
9. PERFORMING ORGANIZATION NAME AND ADDRESS National Eutrophication Survey U.S. Environmental Protection Agency 200 S. W. 35th St. Corvallis, Oregon 97330		10. PROGRAM ELEMENT NO. 11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS Office of Research and Development U.S. Environmental Protection Agency 401 M Street, S. W. Washington, DC 20460		13. TYPE OF REPORT AND PERIOD COVERED Final - 1974 14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES
Prepared in cooperation with the U.S. Environmental Protection Agency, National Environmental Research Center, Las Vegas, Nevada 89114

16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
eutrophication lakes nutrients phosphorus nitrogen loading		05H 05C

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS (This Report)	21. NO. OF PAGES
Release unlimited	20. SECURITY CLASS (This page)	22. PRICE

EPA Form 2220-1 (9-73)

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's freshwater lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Kansas State Department of Health and Environment for professional involvement, to the Kansas National Guard for conducting the tributary sampling phase of the Survey, and to those Kansas wastewater treatment plant operators who voluntarily provided effluent samples and flow data.

The staff of the Kansas Division of Environmental Health provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

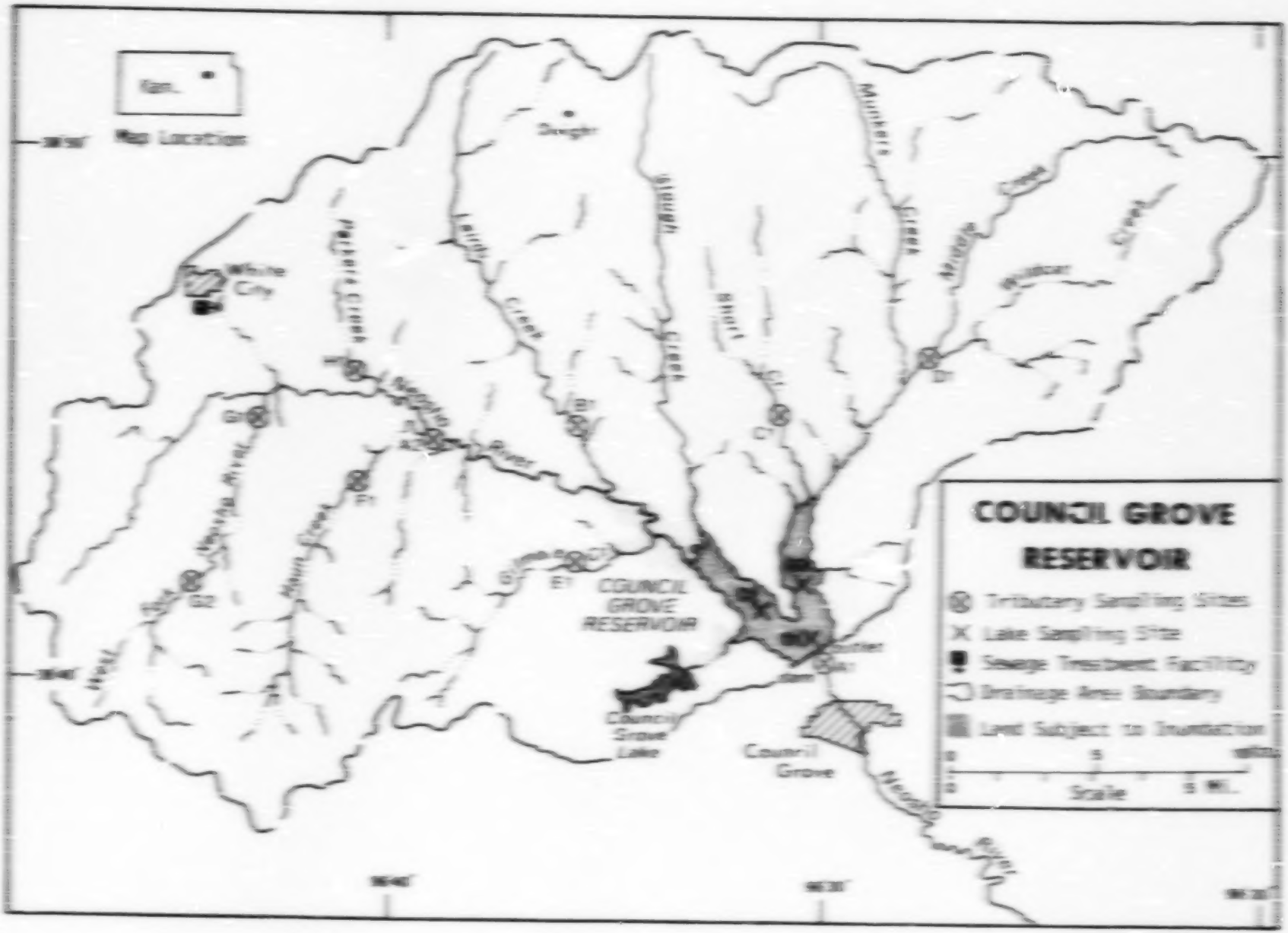
Major General Edward R. Fry, the Adjutant General of Kansas, and Project Officer Colonel Albin L. Lundquist, who directed the volunteer efforts of the Kansas National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY RESERVOIRS

STATE OF KANSAS

NAME	COUNTY
Cedar Bluff	Trego
Council Grove	Morris
Elk City	Montgomery
Fall River	Greenwood
John Redmond	Coffey, Lyon
Kanopolis	Ellsworth
Marion	Marion
Melvern	Osage
Milford	Clay, Geary
Norton	Norton
Perry	Jefferson
Pomona	Osage
Toronto	Greenwood, Woodson
Tuttle Creek	Marshall, Pottawatomie, Riley
Wilson	Russell


Kan.
No Location
White City
Dwight
Latimore Creek
Lost Creek
Rock Creek
Middle Creek
Mercer Creek
Rock Creek
Rock Creek
Rock

COUNCIL GROVE RESERVOIR
STORET NO. 2002

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate Council Grove Reservoir is potentially eutrophic. However, the reservoir becomes quite turbid during periods of runoff, and primary productivity is intermittently light-limited (Kring, 1977).

This water body ranked twelfth in overall trophic quality when the 15 Kansas reservoirs sampled in 1974 were compared using a combination of six lake parameters*. Ten of the reservoirs had less median total phosphorus, median dissolved phosphorus, and median inorganic nitrogen, eight had less mean chlorophyll a, and nine had greater mean Secchi disc transparency.

Survey limnologists did not observe algal concentrations or aquatic macrophytes but noted that the Neosho River arm of the reservoir was quite turbid in April.

B. Rate-Limiting Nutrient:

The algal assay results indicate Council Grove Reservoir was phosphorus limited at the time the samples were taken (04/11/74 and 10/02/74). The reservoir data also indicate phosphorus limitation at those times. However, because of turbidity, the reservoir is intermittently light-limited rather than nutrient-limited.

* See Appendix A.

C. Nutrient Controllability:

1. Point sources--The only known point source, White City, contributed an estimated 2.1% of the total phosphorus load reaching Council Grove Reservoir during the sampling year.

The present phosphorus loading of 2.07 g/m^2/yr is four times that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic loading (see page 13). On the basis of survey data, it does not seem likely that control of phosphorus at the White City wastewater treatment plant would result in any significant improvement in the trophic condition of the reservoir.

2. Non-point sources--Non-point sources contributed 97.9% of the total phosphorus load to the reservoir during the sampling year. The Neosho River added 42.4% of the total; Short Creek, 3.9%; Gilmore Creek, 0.7%; and the ungaged tributaries contributed an estimated 50.1%.

The phosphorus export rates of the Neosho River, Short Creek, and Gilmore Creek were 60, 41, and 6 kg/km^2/yr, respectively (see page 12). The Neosho River and Short Creek rates were substantially higher than the rates of three tributaries of nearby Milford Reservoir* (6, 26, and 30 kg/km^2/yr).

* Working Paper No. 519.

II. RESERVOIR AND DRAINAGE BASIN CHARACTERISTICS†

A. Morphometry††:

1. Surface area: 13.27 kilometers².
2. Mean depth: 3.9 meters.
3. Maximum depth: 12.8 meters.
4. Volume: 51,753 x 10^5 m^3.
5. Mean hydraulic retention time: 218 days (based on outflow).

B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage Area (km^2)*	Mean flow (m^3/sec)*
Neosho River	192.7	0.900
Short Creek	26.2	0.129
Gilmore Creek	29.8	0.145
Minor tributaries & immediate drainage -	385.5	2.050
totals	634.2	3.224

2. Outlet -

Neosho River	647.5**	2.750

C. Precipitation***:

1. Year of sampling: 82.3 centimeters.
2. Mean annual: 87.2 centimeters.

† Table of metric conversions--Appendix B.
†† Stoltenberg, 1975.
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976".
** Includes area of reservoir.
*** See Working Paper No. 175.

III. WATER QUALITY SUMMARY

Council Grove Reservoir was sampled three times during the open-water season of 1974 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from a number of depths at three stations on the reservoir (see map, page v). During each visit, a single depth-integrated (4.6 m or near bottom to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the first and last visits, a single 18.9-liter depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depths sampled were 12.2 meters at station 1, 3.0 meters at station 2, and 4.6 meters at station 3.

The sampling results are presented in full in Appendix D and are summarized in the following table (the June nutrient samples were not properly preserved and were not analyzed).

[illegible] SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR EFFLUENT ENTERING
STUART DAM, 1982

PARAMETER	1ST SAMPLING : 4/13/82 3 SITES RANGE	MEAN	MEDIAN	2ND SAMPLING : 6/23/82 3 SITES RANGE	MEAN	MEDIAN	3RD SAMPLING : 10/ 2/82 3 SITES RANGE	MEAN	MEDIAN
TEMP (C)	10.0 - 11.0	11.0	10.9	22.7 - 24.0	23.6	23.6	15.0 - 15.0	15.0	15.7
DISS OXY (MG/L)	9.0 - 10.2	9.9	10.4	4.0 - 7.0	6.2	6.0	8.0 - 9.0	8.5	8.6
[illegible] (MG/KG)	257. - 278.	264.	262.	240. - 388.	268.	258.	277. - 285.	281.	280.
PH (STAND UNITS)	8.1 - 8.3	8.2	8.2	7.8 - 8.3	8.1	8.1	8.2 - 8.4	8.3	8.2
TOT ALK (MG/L)	157. - 178.	154.	153.	[illegible]	[illegible]	[illegible]	155. - 156.	156.	156.
TOT P (MG/L)	0.073 - 0.252	0.135	0.096	[illegible]	[illegible]	[illegible]	0.027 - 0.061	0.037	0.033
ORTHO P (MG/L)	0.038 - 0.039	0.032	0.033	[illegible]	[illegible]	[illegible]	0.015 - 0.021	0.022	0.023
NO2+NO3 (MG/L)	0.960 - 1.070	1.014	1.018	[illegible]	[illegible]	[illegible]	0.530 - 0.590	0.554	0.552
AMMONIA (MG/L)	0.070 - 0.090	0.041	0.035	[illegible]	[illegible]	[illegible]	0.035 - 0.040	0.037	0.038
KJEL N (MG/L)	0.580 - 1.160	0.711	0.660	[illegible]	[illegible]	[illegible]	0.280 - 0.780	0.430	0.330
INORG N (MG/L)	1.040 - 1.250	1.074	1.081	[illegible]	[illegible]	[illegible]	0.550 - 0.620	0.581	0.580
TOTAL N (MG/L)	1.040 - 2.107	1.085	1.701	[illegible]	[illegible]	[illegible]	0.710 - 0.810	0.786	0.792
CHLOPYL A (UG/L)	11.0 - 13.0	12.7	12.7	1.5 - 3.1	2.1	1.6	4.0 - 26.0	24.0	25.1
SECCHI (METERS)	8.3 - 8.5	8.4	8.4	8.3 - 8.3	8.3	8.3	8.3 - 8.5	8.4	8.5

B. Biological characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
04/11/74	1. Ankistrodesmus sp.	1,140
	2. Chroomonas sp.	1,020
	3. Stephanodiscus sp.	900
	4. Melosira sp.	330
	5. Cryptomonas sp.	270
	Other genera	331
	Total	3,991
06/25/74	1. Chroomonas sp.	527
	2. Melosira sp.	176
	3. Stephanodiscus sp.	70
	4. Closterium sp.	35
	5. Skeletonema sp.	35
	Other genera	36
	Total	879
10/02/74	1. Cyclotella sp.	1,583
	2. Chroomonas sp.	762
	3. Stephanodiscus sp.	293
	4. Ankistrodesmus sp.	59
	5. Cryptomonas sp.	59
	Other genera	59
	Total	2,815

2. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (µg/l)
04/11/74	1	11.6
	2	13.9
	3	12.7
06/25/74	1	1.6
	2	3.1
	3	1.6
10/02/74	1	8.6
	2	20.0
	3	16.1

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

a. April sample -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.020	0.865	6.1
0.050 P	0.070	0.865	17.3
0.050 P + 1.0 N	0.070	1.865	25.3
1.0 N	0.020	1.865	6.5

b. October sample -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.030	0.575	9.6
0.050 P	0.080	0.575	16.9
0.050 P + 1.0 N	0.080	1.575	17.7
1.0 N	0.030	1.575	10.9

2. Discussion -

The control yields of the assay alga, Selenastrum capricornutum, indicate that the potential primary productivity of Council Grove Reservoir was high at the times the assay samples were collected (04/11/74 and 10/02/74). In both assays, an increase in yield occurred when phosphorus was added alone, but no significant increase occurred when only nitrogen was added. These results indicate the reservoir was phosphorus limited at the times the samples were taken.

The reservoir data also indicate phosphorus limitation. The mean inorganic nitrogen to orthophosphorus ratios were 37 to 1 in April and 26 to 1 in October, and phosphorus limitation would be expected. However, the reservoir is intermittently light-limited rather than nutrient-limited (Kring, 1977).

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the Kansas National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the high runoff months of May and July when two or three samples were collected. Sampling was begun in October, 1974, and was completed in September, 1975.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Kansas District Office of the U.S. Geological Survey for the tributary sites nearest the reservoir.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings*. Nutrient loads shown are those measured minus point-source loads, if any.

Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the means of the nutrient loads, in kg/km^2/year, at stations A-2, C-1, and E-1 and multiplying the means by the ZZ area in km^2.

The operator of the White City wastewater treatment plant provided monthly effluent samples but could not provide flow data. Therefore, nutrient loads were estimated at 1.134 P and 3.401 N/capita/year, and flows were estimated at 0.3785 m^3/capita/day.

* See Working Paper No. 175.

A. Waste Sources:

1. Known municipal* -

Name	Pop. Served	Treatment	Mean Flow (m^3/d)	Receiving Water
White City	517	tr. filter + pond	195.7	Dry Creek

b. Known industrial - None

* Treatment plant questionnaire.

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/ yr	% of total
a. Tributaries (non-point load) -		
Neosho River	11,650	42.4
Short Creek	1,065	3.9
Gilmore Creek	180	0.7
b. Minor tributaries & immediate drainage (non-point load) -	13,760	50.1
c. Known municipal STP's -		
White City	585	2.1
d. Septic tanks - Unknown	?	-
e. Known industrial - None	-	-
f. Direct precipitation* -	230	0.8
Total	27,470	100.0

2. Outputs -

Reservoir outlet - Neosho River 9,010

3. Net annual P accumulation - 18,460 kg.

* See Working Paper No. 17b.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (non-point load) -		
Neosho River	134,250	29.8
Short Creek	23,010	5.1
Gilmore Creek	14,190	3.1
b. Minor tributaries & immediate drainage (non-point load) -	263,565	58.4
c. Known municipal STP's -		
White City	1,760	0.4
d. Septic tanks - Unknown	?	-
e. Known industrial - None	-	-
f. Direct precipitation* -	14,325	3.2
Total	451,100	100.0

2. Outputs -

Reservoir outlet - Neosho River	165,745

3. Net annual N accumulation - 285,355 kg.

D. Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km²/yr	kg N/km²/yr
Neosho River	60	697
Short Creek	41	676
Gilmore Creek	6	476

* See Working Paper No. 175.

E. Mean Nutrient Concentrations in Ungaged Streams:

Tributary	Mean Total P Conc. (mg/l)	Mean Total N Conc. (mg/l)
Lairds Creek	0.146	2.654
Middle Creek	0.192	2.951
Haun Creek	0.096	2.520
W. Fk. Neosho River (G-1)	0.150	2.690
W. Fk. Neosho River (G-2)	0.167	2.708

F. Yearly Loads:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m^2/yr	2.07	1.39	34.0	21.5

Vollenweider phosphorus loadings ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Council Grove Reservoir:

"Dangerous" (eutrophic loading)	0.50
"Permissible" (oligotrophic loading)	0.25

V. LITERATURE REVIEWED

Kring, R. Lynn, 1977. Personal communication (primary productivity in reservoir). KS Dept. of Health & Environment, Topeka.

Stoltenberg, Gerald A., 1975. Personal communication (reservoir morphometry). KS Dept. of Health & Environment, Topeka.

Vollenweider, R. A., and P. J. Dillon, 1974. The application of the phosphorus loading concept to eutrophication research. Natl. Res. Council of Canada Publ. No. 13690, Canada Centre for Inland Waters, Burlington, Ontario.

VI. APPENDICES

APPENDIX A

LAKE RANKINGS

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	[illegible] TOTAL P	[illegible] INORG N	[illegible] [illegible] SEC	[illegible] CHLOPH	[illegible] [illegible] III	[illegible] SECCHI DEPTH P
2001	CEDAR BLUFF RESERVOIR	0.017	0.495	43.667	4.237	10.920	0.854
2002	COUNCIL GROVE	0.069	0.438	45.894	6.789	10.445	0.629
2003	ELK CITY	0.038	0.546	48.408	3.202	24.000	0.803
2004	FALL RIVER RESERVOIR	0.053	0.478	48.667	7.483	9.238	0.529
2005	JOHN REDMOND RESERVOIR	0.116	1.258	42.667	5.467	8.200	0.296
2006	KANOPOLIS RESERVOIR	0.056	0.648	47.000	24.433	10.200	0.611
2007	MARION RESERVOIR	0.052	0.431	43.667	12.468	9.000	0.600
2008	MELVERN RESERVOIR	0.034	0.265	49.111	10.488	24.400	0.867
2009	MILFORD RESERVOIR	0.075	0.724	46.333	15.823	13.455	0.626
2010	NORTON RESERVOIR	0.122	0.138	43.750	23.268	8.286	0.426
2011	PERRY RESERVOIR	0.055	0.478	45.571	5.634	13.400	0.667
2012	POMONA RESERVOIR	0.048	1.248	41.333	6.302	13.889	0.421
2013	TORONTO RESERVOIR	0.067	0.425	48.538	6.593	13.800	0.611
2014	TUTTLE CREEK RESERVOIR	0.102	0.478	43.667	11.279	13.688	0.667
2015	WILSON RESERVOIR	0.023	0.265	46.222	8.867	13.400	0.854

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CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

Reproduced from best available copy.

APPENDIX D

PHYSICAL and CHEMICAL DATA

[illegible]

APPENDIX F

TRIBUTARY AND WASTEWATER TREATMENT PLANT DATA

[illegible]

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[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

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DATE	TIME	DEPTH	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
FROM	OF	THROUGH	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TO	DAY	FEET	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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DATE	TIME	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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74/10/11	16 32	5.425	2.132	3.347	0.186	0.276
74/10/09	11 18	2.849	4.881	0.958	0.840	0.840
74/10/13	15 09	1.760	1.383	0.815	0.815	0.815
75/01/12	11 36	4.264	2.389	0.884	0.889*	0.946
75/02/09	12 14	1.468	2.388	-.032	0.829	0.947
75/03/05	11 19	1.445	0.459	0.124	0.389*	0.819
74/04/13	11 29	1.571	1.709	0.940	0.219	0.838
75/05/02	17 31	1.158	1.859	0.738	0.825	0.838
75/05/14	11 00	1.881	0.159	0.838	0.825	0.828
75/05/25	10 15	0.946	0.958	0.836	0.835	0.886
75/06/11	11 48	0.910	0.758	0.885	0.825	0.860
75/07/11	14 42	0.670	0.488	0.815	0.836	0.886
75/07/25	10 08	1.386	1.958	0.866	0.829*	
75/08/04	14 35	0.670	0.758	0.828	0.838	0.878
75/09/22	15 32	3.886	0.989	0.832	0.815	0.835

* VALUE [illegible] TO BE
LESS THAN INDICATED

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